Annals B. Agric. 1 (1): 33 – 39, 1991

FOLIAR FERTILIZATION OF NITROGEN IN MUNGBEAN: INFLUENCE OF RATE AND FREQUENCY OF APPLICATION

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Abstract

The influence of rate and frequency of foliar N fertilization on the yield performance and nutrient uptake of mungbean had been evaluated in a series of experiments. Foliar applied N generally increased seed yield over the untreated control excepting the treatment with 20 mg N l^{-1}. A concentration of 10 mg N l^{-1} was most beneficial to pod and seed development than the higher or lower concentrations. Spraying N at around flowering caused significant yield increase but application twice (at around flowering and at late reproductive phase) gave significantly greater seed yield than any single application. Field experiment also confirmed that foliar N at 10 mg l^{-1} applied twice in the reproductive phase gave greater yield advantage.

Key words: Foliar fertilization, Nitrogen, Mungbean

Introduction

Mungbean (*Vigna radiata* (L.) Wilczek) is one of the major sources of vegetable protein in many parts of tropical Asia. It is grown extensively in both tropical and temperate regions (Summerfield and Lawn, 1988) under diverse agroclimatic conditions. However, yield of the crop is generally low. Among the probable reasons for low yield potentials high requirement of nitrogen for the formation and development of grains stands prominent (Mitra *et al.*, 1988). Mungbean needs much more N during the reproductive development than it does in the vegetative stage. To produce one unit of seeds, mungbean needs nitrogen as much as threee times greater than it is needed by cereal crops like rice (Sinclair and de Wit, 1975). Despite its ability to fix atmospheric N, mungbean cannot meet its N requirement. Recently Mitra *et al.* (1988) showed that a moderate yielding mungbean crop requires about 28 mg N g^{-1} photosynthate during the 20 days of pod and seed development. Conversely, nutrient uptake after flowering either slows down or stops because of root inactivation and less than 40% of N required for sustaining growth and development is met through the soil supply. Generally during the reproductive growth of grain legumes most of the N demand for grain development is met through the remobilization of N and assimilates from the leaves or other organs and their transport to seed is an essential feature in the reproductive phase. Such remobilization enhances early senescence and reduces grain growth duration; the phenomenon which Sinclair and de Wit (1975) referred to self destruction of plants.

However, senescence and withdrawal of N from vegetative parts of the crop may not be essential for seed production (Sheehy, 1983) provided the remobilization of N from photosynthesizing leaves can be stopped or reduced by supplemental N application. In view of root inactivation during the post-anthesis period (Mitra *et al.*, 1988), foliar feeding of nitrogen may help meet the increased N demand. Foliar fertilization of N has been reported to be beneficial in a number of crops including soybean (Garcia and Hanway, 1976; Ashour and Thalooth, 1983), cowpea (Elowad and Hall, 1987) and grain crops (Kargbo, 1985). However there are conflicting reports on the effect of foliar applied urea in growth and yield formation of those crops. Reports of adverse effects of foliar fertilization on the crops performance has also been reported (Parker and Boswell, 1980). The factors responsible for the success of foliar fertilization have been reviewed extenstively. Concentration of nutrient solution and stage of crop development when fertilizer is applied have large bearing on the success of foliar application of nutrients.

The objective of the present study was to evaluate the effect of foliar application of urea and to determine the optimal concentration of N in urea solution and growth stage of mungbean when to spray nutrient solution for optimizing seed yield.

Materials and Methods

Two pot experiments and one field experiment using mungbean (cv. Mubarik) were conducted in this study.

Experiment 1

Seeds were planted in base perforated 22 cm diameter pots filled with 5 kg soil. The soil used was taken from Ap horizon of a Grey Terrace soil (Typic Haplaquept) obtained from the Institute of Postgraduate Studies in Agriculture farm, Salna, Gazipur, Bangladesh, The soil was poorly drained and slightly acidic (pH 5.5) having low organic matter (1.12%) and nitrogen (0.08%) contents with CEC of 8.25 meq/100 g. In each pot a basal dose of 120 mg N, 70 mg P, and 130 mg K in the form of urea, triple superphosphate, and muriate of potash, respectively was incorporated into the soil one day prior to sowing. Five to six seeds were planted in each pot. The plants were kept in a vinyl house and grown in dry season. At the first trifoliate stage, 10 days after emergence (DAE), plants were thinned to retain two healthy plants per pot. Plants were regularly irrigated in order to avoid water stress.

At about first bloom stage, treatments involving foliar application of N was imposed on the plants. Treatments were applied during early morning (Poole *et al.*, 1983). The treatments consisted of four different concentrations of N solutions of fertilizer urea (viz. 0.5, 1.0, 1.5 and 2.0% N equivalent to 5, 10, 15 and 20 mg N 1^{-1} water) with a no-nitrogen control. At each application a volume of 10 ml solution per pot (equivalent to 1500 1 ha $^{-1}$) was sprayed from above on the plants by using a small sprayer (Model # 22612 Canyon, Earth Chemical Co. Ltd., Ako, Japan). Twenty pots were randomly assigned to each treatment.

Following the foliar application of N, 10-12 youngest fully expanded leaves of plants from each individual treatments were sampled twice in the reproductive phase: once at 33 DAE and subsequently at 45 DAE. Leaves were dried at 70^{o}c for 48 h, ground to pass 40 mesh screen. Composite leaf samples were analyzed for total N (Nelson and Sommer, 1973).

The matured pods were harvested thrice and seed yield and components of yield recorded. Data on yield and yield components were subjected to statistical analysis and means compared using LSD test.

Experiment 2

Mungbean plants were established in pots and grown in the following summer season under a vinyl house as described under Experiment 1. Plants were sprayed with urea solution (1.0 N% i.e. 10 mg N l^{-1}) at 4 weeks after emergence (4 WAE), 6 weeks after emergence (6 WAE), or both at 4 weeks and 6 weeks after emergence (4+6 WAE). A control treatment was also included in which mungbean plants were not fertilized with N but sprayed with water. Thus the experiment included four treatments with 20 pots assigned to each. The treatments were arranged in a completely randomized design. Five randomly selected plants were harvested by cutting at the base at 33 DAE and 45 DAE. Ten youngest fully expanded leaves were sampled from each treatment for determination of leaf N content as described in Experiment 1. On both occasions a separate estimate of total N uptake was made determining tissue N concentration using the whole plant sample.

Experiment 3

The third experiment carried out in the Institute of Postgraduate Studies in Agriculture farm was established in the following dry season (March-May) on clay soil from where soils were collected for the Experiments 1 & 2. A basal application of fertilizer at 30 kg N, 20 kg P and 30 kg K in the form of urea, triple superphosphate and muriate of potash respectively, was incorporated into the soil. Seeds were hand planted on plots measuring 3 x 5 m in rows 0.30 m apart at a spacing of 0.10 m between the plants on a row. The treatments consisted of supplemental dose of nitrogen as foliar applied urea solution consisting of 0.5, 1.0 and 1.5 % N (representing 5 mg, 10 mg and 15 mg N l^{-1}, respectively). For each level of foliar N application, spraying was done once (4 WAE) or twice (4+6 WAE). The treatments were arranged randomly using 3 x 2 factorial design with four replications. The effect of foliar application of N and frequency of applicatin on the seed yield were measured by harvesting mature pods on three occasions using six central rows from each plot. Yield attributes were measured using a subsample of 10 plants from each plot. The data were subjected to statistical analysis using model appropriate for factorial design and means separation was done using LSD test.

Results

Experiment 1

Spraying N during reproductive development significantly influenced the seed yield (Table 1). Of the four N levels, the levels in the lower concentrations resulted in higher seed yield over the untreated plants. Foliar treatments of 10 mg N l^{-1} was superior to all other treatments and spraying 20 mg N l^{-1} did not significantly affect seed yield. Intermediate but significantly higher yield was obtained with 5 mg and 15 mg N l^{-1}.

Table 1. Influence of rate of foliar applied N on seed yield and yield attributes of mungbean. (Experiment 1).

Rate (mg N l^{-1})	Seed yield (g $plant^{-1}$)	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	Seed size (mg)
o	2.61	9.17	8.11	30.03
5	3.08	11.06	10.33	30.14
10	3.70	11.80	11.38	28.08
15	3.04	11.10	9.20	27.26
20	2.53	10.10	9.20	27.25
LSD 0.05	0.35	1.29	1.14	NS
CV (%)	10.62	8.54	9.61	3.26

Foliar application of N influenced most of the yield components (Table 1). Regardless of concentrations, N treated plants produced greater number of pods over the untreated ones. Treating with 5 mg N l^{-1} or 10 mg N l^{-1} resulted in increase in number of seeds/pod. Seed size remained unaffected by foliar N fertilization.

Although leaf N decreased with the advance of plant's age, foliar N treatments generally helped retain higher leaf N concentration during the reproductive growth stage. From Table 2 it appears that plants had relatively higher leaf N concentrations as a result of the spray treatments. Generally higher the N concentration in the spray higher was the leaf N concentration, particularly during the later phase of reproductive development (45 DAE).

Table 2. Influence of rate of foliar applied N on leaf nitrogen content of mungbean. (Experiment 1).

Rate (mg N l^{-1})	Leaf N concentration (%)	
	35 DAE	45 DAE
0	4.48	3.17
5	4.97	3.63
10	5.08	3.78
15	5.08	3.82
20	5.15	3.91

Experiment 2

Foliar N treatment effect on seed yield was greatly influenced by the application frequency (Table 3). Maximum seed yield was obtained when urea solution at 10 mg N l^{-1} was sprayed twice— once at 4 WAE and subsequently at 6 WAE. Compared with Experiment 1, foliar N effect was more pronounced in the second experiment giving greater yield advantage (about 70% over control). Supplemental N application generally increased the number of pods per plant signficantly.

Table 3. Effect of foliar application of N at different growth stages of mungbean on seed yield and yield attributes. (Experiment 2).

Stage and frequency of spray	Seed yield (g plant^{-1})	No. of pods plant^{-1}	No. of seed pod^{-1}	Seed size (mg)
Control	3.10	10.8	10.07	28.47
4 WAE	4.55	14.9	10.53	29.07
6 WAE	4.03	12.1	11.47	29.00
4 WAE + 6 WAE	5.25	14.9	11.74	30.02
LSD 0.05	0.87	1.54	1.03	NS
CV (%)	11.03	2.12	6.24	2.15

However, single application at the reproductive phase was superior to the application at the later phase. Number of seeds per pod also tended to increase with supplemental N application at 6 WAE.

Leaf tissue analysis showed little variation in leaf N content immediately after first application of urea solution (Table 4). But three days after the second application considerable response was apparent. Variation in the uptake of total N seemed to have mainly governed by total dry mátter accumulation.

Table 4. Influence of the frequency of foliar N spray on the leaf N concentration and total N uptake during the reproductive stage of mungbean. (Experiment 2).

Stage & Frequency of spray	Leaf N concentration (%)		Total N uptake (mg plant^{-1})	
	33 DAE	45 DAE	33 DAE	45 DAE
Control	4.16	3.33	110	127
4 DAE	4.42	3.71	130	151
6 DAE	4.16	3.50	112	134
4 WAE + 6 WAE	4.42	3.88	139	177

Experiment 3

Effect of foliar application of N in relation to concentration and application frequency on mungbean performance as obtained from field experiment is summarized in Table 5.

Seed yield varied considerably depending on spray concentrations giving significantly higher yield (133 g plant $^{-1}$) for an intermediate concentration of 10 mg N 1^{-1} over the other two treatments. Variations in spray concentration resulted in significant differences in all three important components of seed yield; but there was about 35% increase in number of pods/plant. Spraying 5 mg N 1^{-1} gave fewer seeds/pod compared with other treatments. Largest seeds were produced when plants were treated with 10 mg N 1^{-1} but further increase in concentration had a negative effect on seed size, although the magnitude of difference was not great.

Application at both at 4 WAE and 6 WAE gave better seed yield than it was observed in plants sprayed only at 4 WAE (Table 5); the yield differences were due mainly to the variation in number of pods/plant.

Interaction between concentration and stage or time of application in relation to yield or its components was not statistically significant.

Results of all three experiments indicate that foliar N treatments during reproductive development had mixed effects on seed yield. Both the spray concentration and time of application exerted significant influence on the effect of foliar N fertilization. Foliar N at 5 or 15 mg 1^{-1} generally increased seed yield but a concentration of 10 mg N 1^{-1} was consistently found to be superior giving 42% increased yield compared to the yield obtained without foliar treatment. Likewise spraying N twice in the reproductive phase showed yield increase consistently. A similar trend was also observed in the field experiment. The results are in agreement with Mitra *et al.* (1988) who obtained 8-57% increased seed yield in mungbean through foliar application of urea at a concentration of 1.5%, depending on varieties.

Table 5. Effect of foliar application of N on the performance of mungbean in relation to rate and time of application (Experiment 3).

Treatments	Seed yield (g m^{-2})	No. of pods plant^{-1}	No. of seeds pod^{-1}	Seed size (mg)
Rate (mg N 1^{-1})				
5	89.50	11.20	9.00	30.30
10	133.00	14.25	10.20	31.20
15	97.00	10.95	9.70	29.20
LSD 0.05	14.00	1.18	0.80	0.90
Application Frequency				
4WAE	96.00	11.93	9.17	30.40
4 WAE + 6 WAE	117.00	12.33	10.10	30.03
LSD 0.05	13.00	NS	0.72	NS
CV (%)	8.90	12.42	9.33	2.08

Several authors (Mitra *et al.*, 1988; Parker and Boswell, 1980) observed leaf burning due to high concentration of nutrient solution. However, in our experiments even the plants treated with the highest concentration (20 mg N l^{-1}) did not exhibit leaf burning symptoms. The reasons for lack of response to foliar application of at high concentrations were not apparent.

Variation in seed yield due to foliar N treatments can be best explained from analyzing the yield components. Both the rate and stage of foliar application exerted significant influence on the number of pods/plant and seeds/pod; but the effect was pronounced in the number of pods/plant. There was a significant linear relationship ($p = 0.001$) between the number of pods/plant and seed yield/plant ($Y = 0.446\ x - 1.7088$, $R^2 = 0.9198$; where Y = seed yield per plant in g, x = number of pods/plant) suggesting that seed yield increased with increase in pods/plant. Almost a similar relationship between the number of seeds/pod and per plant seed yield was observed. In a separate study (M. N. Islam. 1987. Unpublished data) it was observed that foliar spray of N (5 mg N l^{-1}) reduced flower abscission and consequently resulted in significant increase in pods/plant. Our results compare favorably with those of Brevedan *et al.* (1978) who reported that suplemental N treatment during reproductive period increased grain yield of soybean through the increase in pods/plant and reducing flower and pod abscission.

Kuo *et al.* (1978) suggested that seed yield increase in mungbean might be limited by leaf photosynthetic activity during the reproductive period. Leaf photosynthetic rate declines with age which has been associated with a decline in leaf elements (Ojima *et al.*, 1975). Natr (1975) indicated that N deficiency was more detrimental to photosynthesis than P and K deficiency. Foliar fertilization of N is expected to enhance N concentration in plants and increase yield maintaining C balance. In the present study foliar N treatments tended to increase leaf N content and total N uptake although the effect of increased leaf N concentration on seed yield was inconsistent. Supplemental N application either as foliar spray or through soil enhances photosynthetic activities (Mitra *et al.*, 1988) and increases grain-filling period by delaying senesience. However, leaf senescence in mungbean prior to seed maturity was not pronounced in our study and the effect of foliar N treatment on grain filling duration was not apparent. Boote *et al.* (1978) also obtained similar results in soybean with foliar fertilization. They reported that increase in leaf N failed to arrest senescence or extend leaf photosynthetic activities.

Mungbean is usually grown under low fertility level and as a result the crop often encounters nutrient stress including nitrogen deficiency particularly in the reporductive stage. The small starter dose of N perhaps is of little use in view of slow growth at the early vegetative phase (Kuo *et al.*, 1978) and it is unlikely that basally applied N is taken up by the plant during the reproductive stage when N demand is the highest. Moreover, mungbean's ability to fix atmospheric nitrogen is reported to be the lowest among the grain legumes (Rachie and Roberts, 1974). In an earlier report we (Hamid, 1988) showed that mungbean responded favorably to the application of N during the post-flowering phase. Response to foliar N fertilization in this study indicates that supplemental N application during the reporductive development might be essential for achieving optimum growth and yield production of mungbean.

Acknowledgement: The author wishes to thank Dr. Harold W. Youngberg for critical reading of the manuscript.

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